

Self-Decontaminating Materials & Multifunctional Coatings Workshop



In Search of the Silver Bullet: The Reactive Solution

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Self-Decontaminating Materials

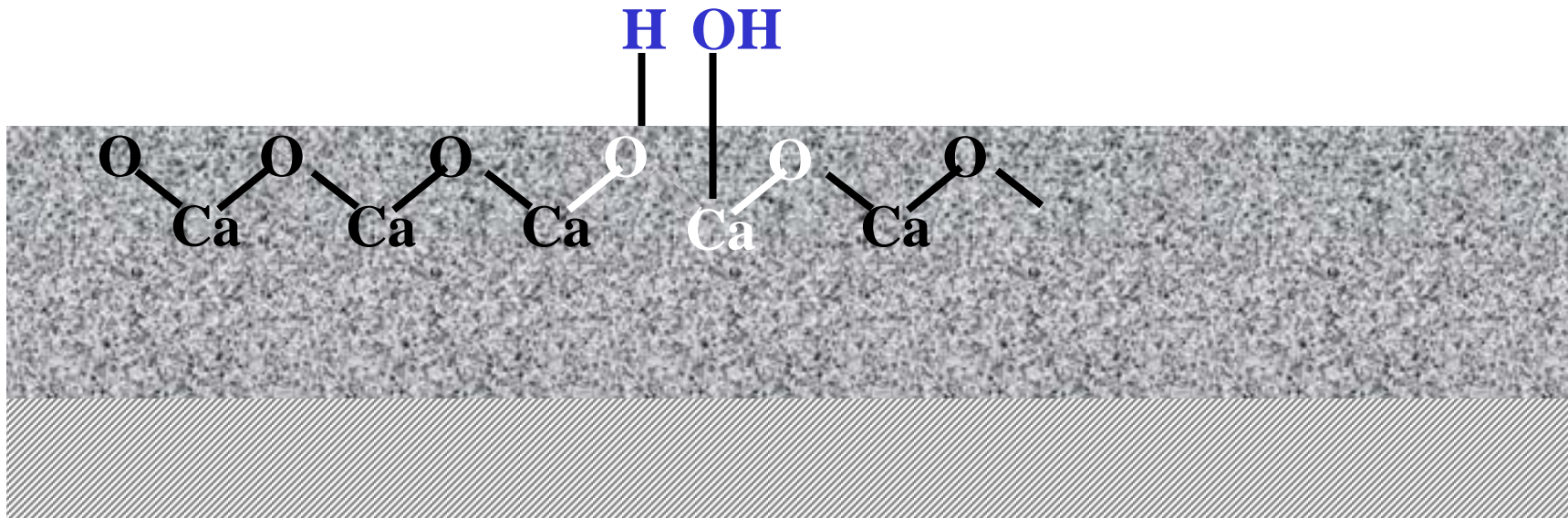
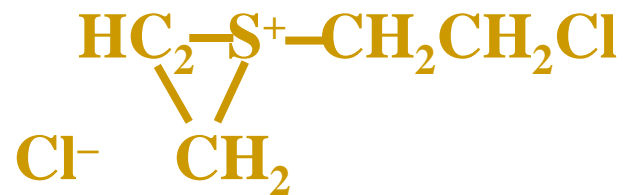
CONCEPT:

Development of 'upgradeable' coatings and textile treatments that will react to neutralize and/or entrain pathogens, toxic industrial chemicals/materials (TIC/M), radioisotopes, and/or chemical agents on contact.

The property of self-decontamination may reside in one or more components rather than throughout complete systems.

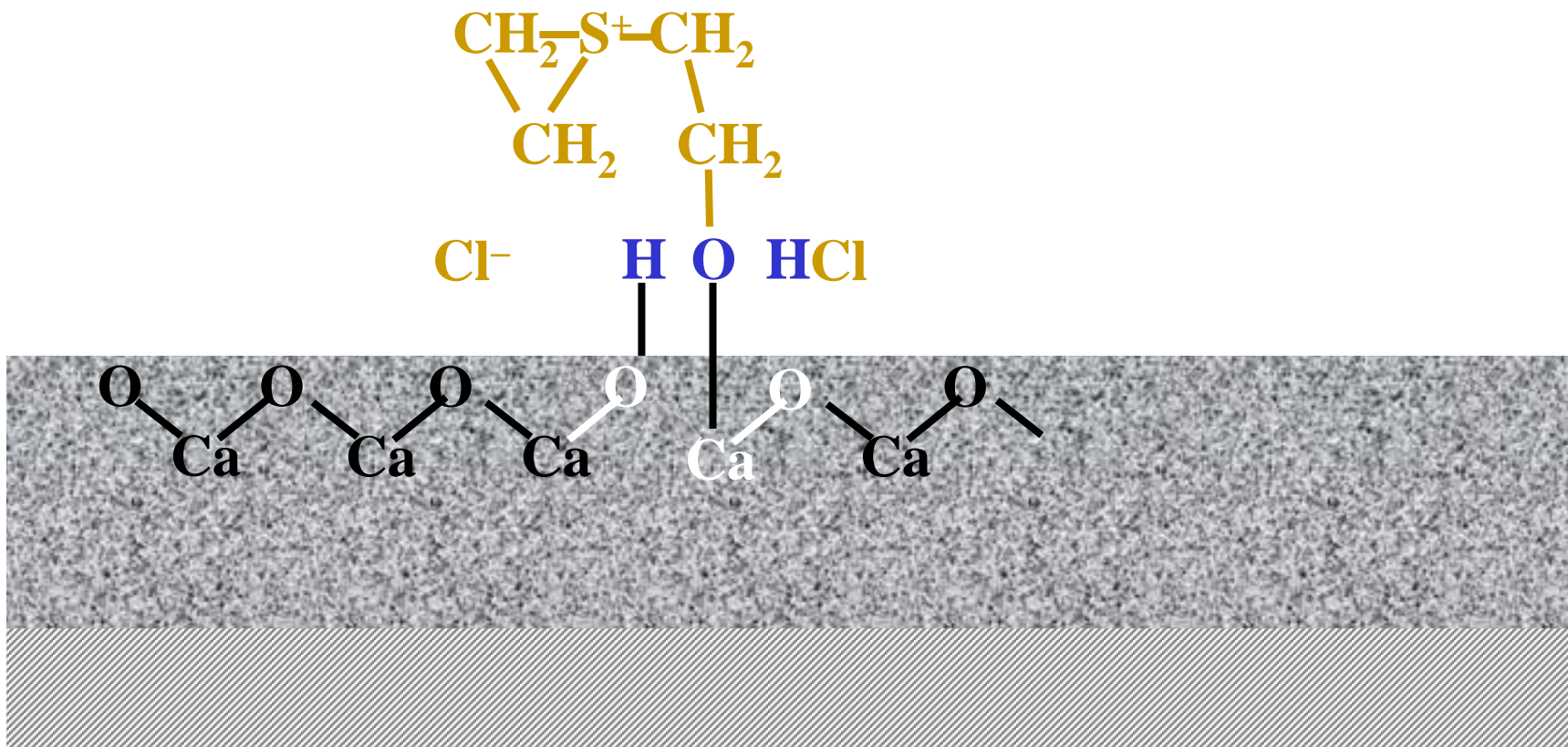
Intrinsic Self-Decontaminating Material

HD on concrete surface



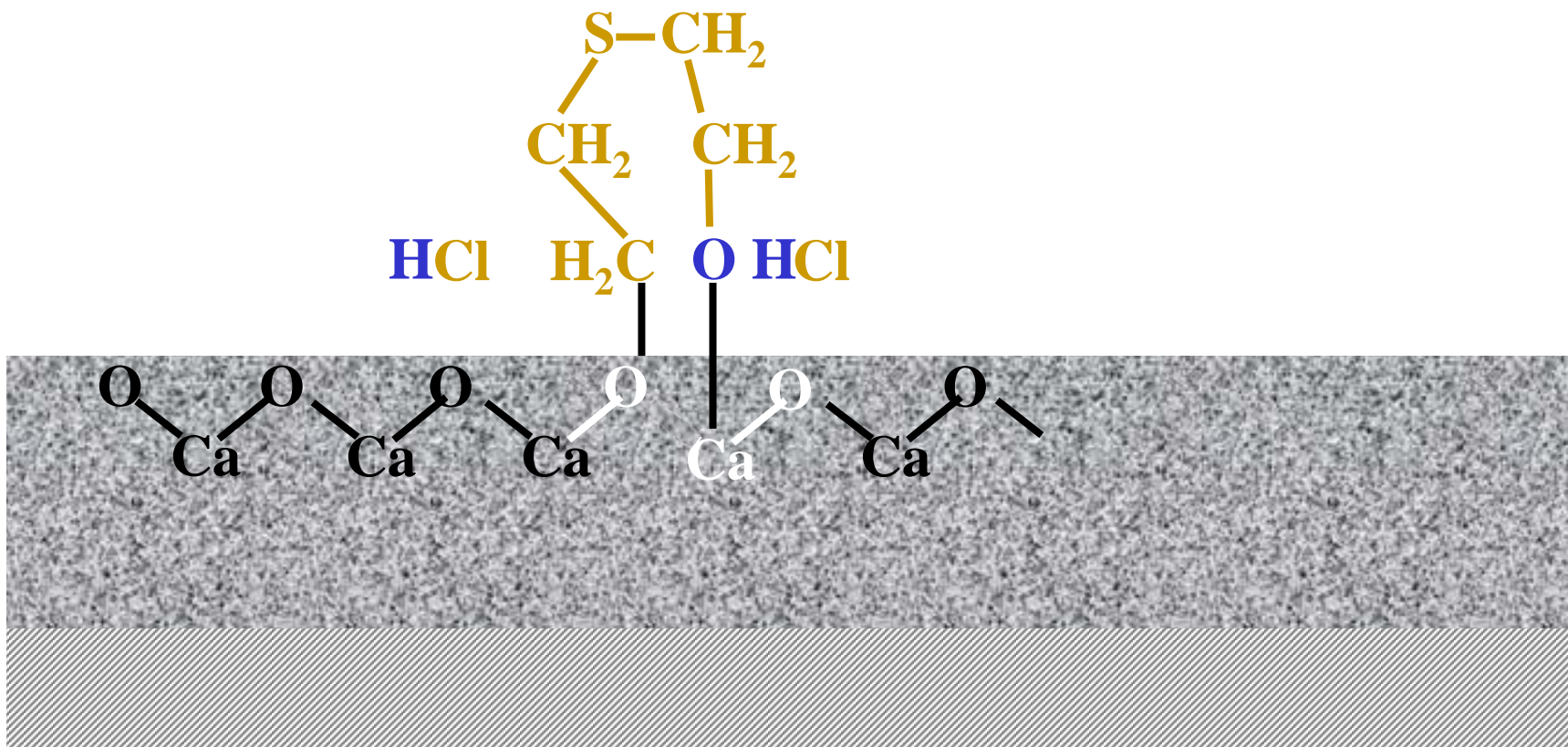
Intrinsic Self-Decontaminating Material

HD on concrete surface



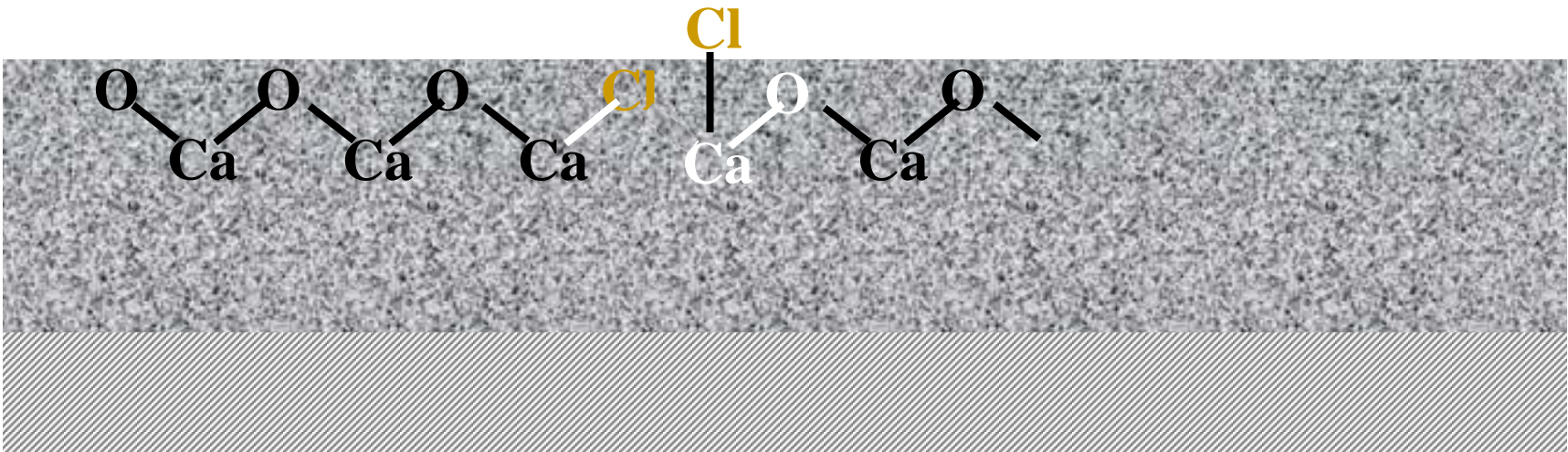
Intrinsic Self-Decontaminating Material

HD on concrete surface



Intrinsic Self-Decontaminating Material

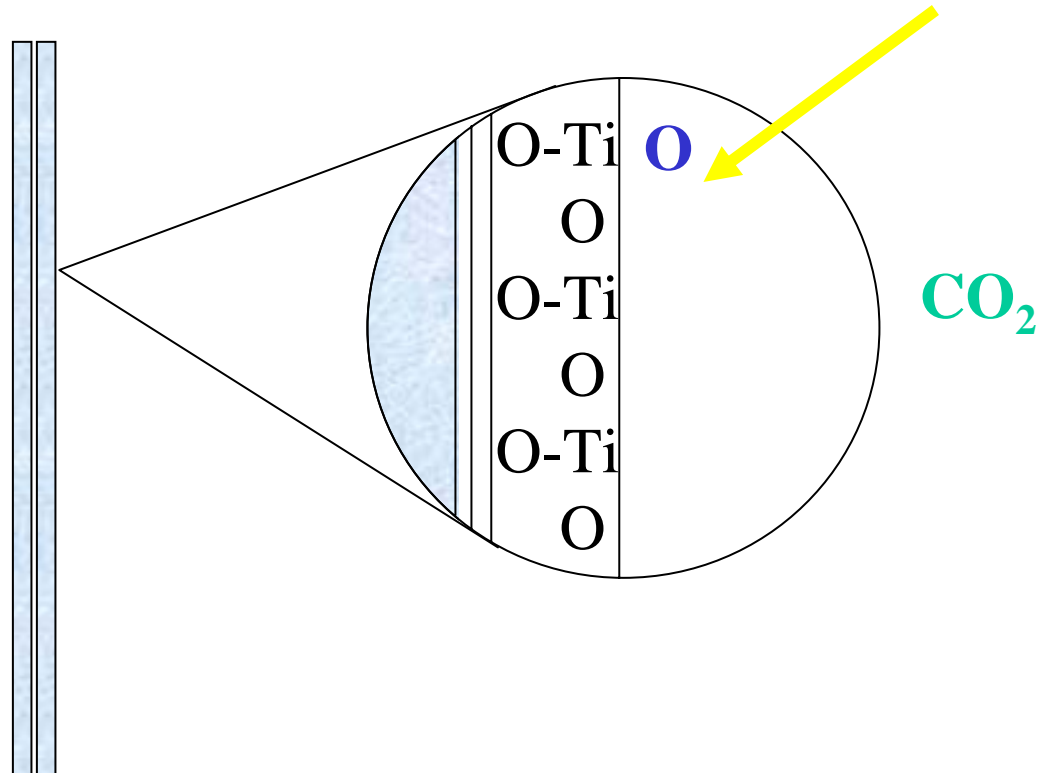
HD on concrete surface



Commercially Available Self-Decontaminating Material

PHOTOCATALYTIC (SELF-CLEANING) GLASS:

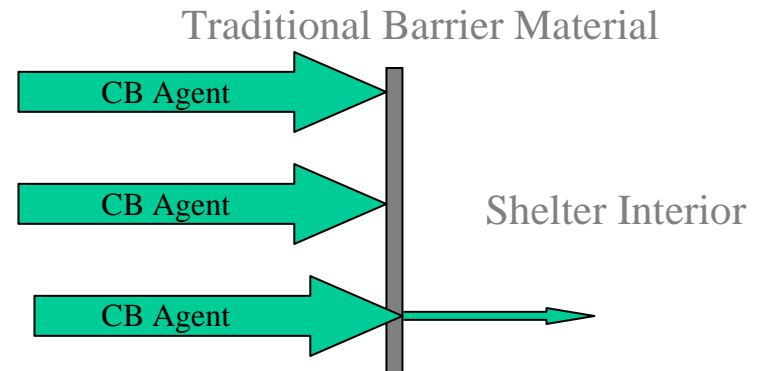
Layered, composite material. Excludes most infrared.



Technical Approach

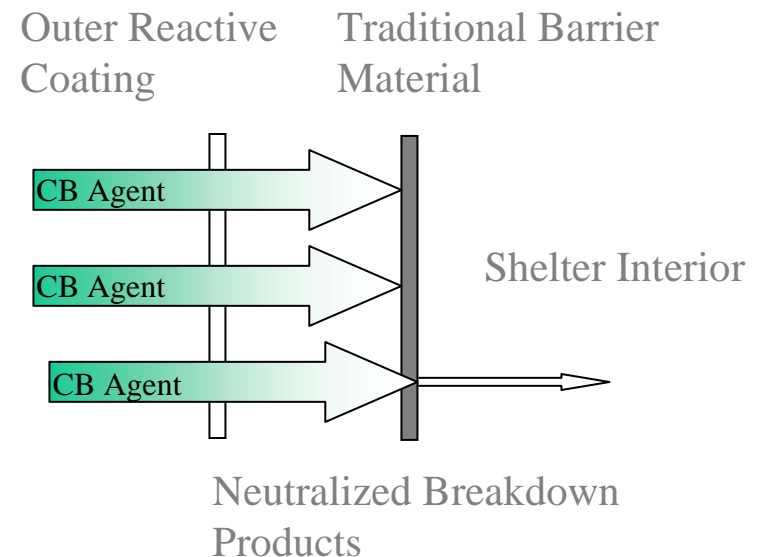
“Impermeable” Barrier Materials

- All barrier materials will fail (72 hours for current systems)
- Hermetic isolation => environmental stress
- Better barrier materials => to higher costs



Reactive/Barrier Materials

- Neutralization products as the surface act as prophylactic
- Only neutralized products permeate through the reactive barrier component
- Shelter materials can now be made using less expensive barrier materials augmented with a reactive coatings



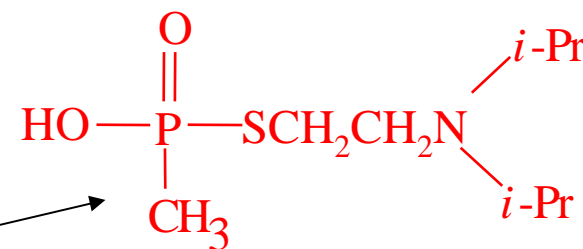
What We Have

Kills Bugs

- cell toxicity
- membrane disruption
- oxidation

Neutralize VX

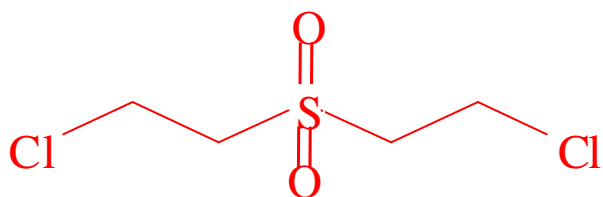
- oxidation
- hydrolysis
- nucleophilic attack



EA2192

Neutralize G-agents

- hydrolysis
- nucleophilic attack

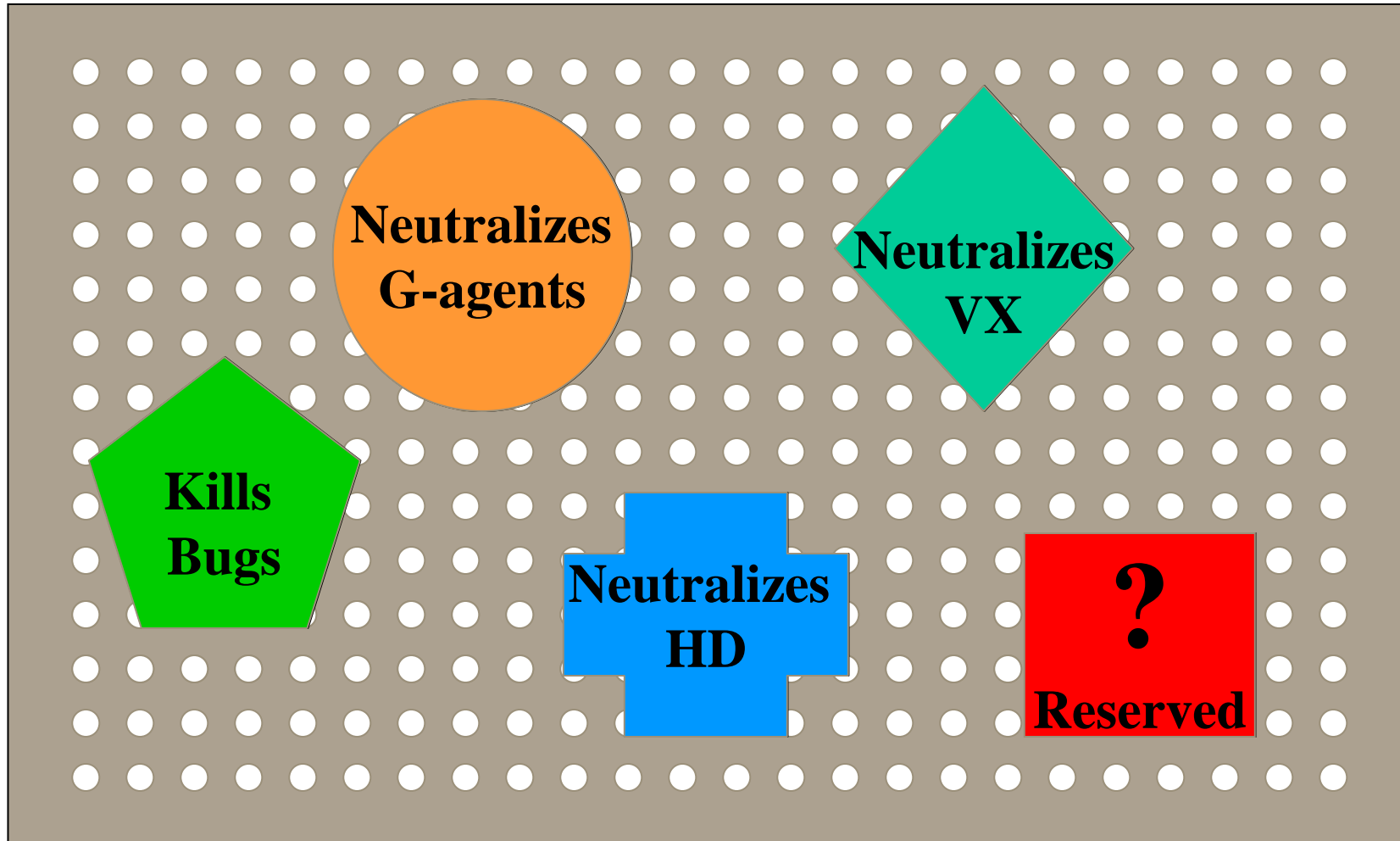


HD-Sulfone

- oxidation
- hydrolysis

Neutralize HD

What We Want



Reactive Monomer Criteria

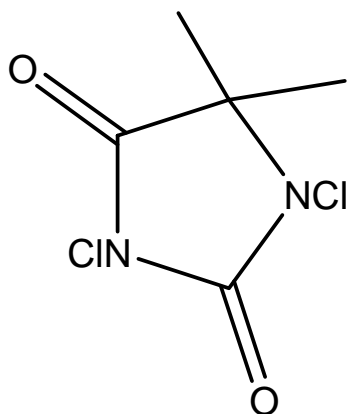
- Active against the things we're worried about
- Neutralization products relatively non-toxic
- Non-specific
- Catalytic or regenerable
- Contain sacrificial attachment functionality
- Mustn't significantly degrade each other or the polymer matrix

Reactive Monomer Selection

Weak oxidizers within a band of reactivity that targets specific functional groups

Chloramides

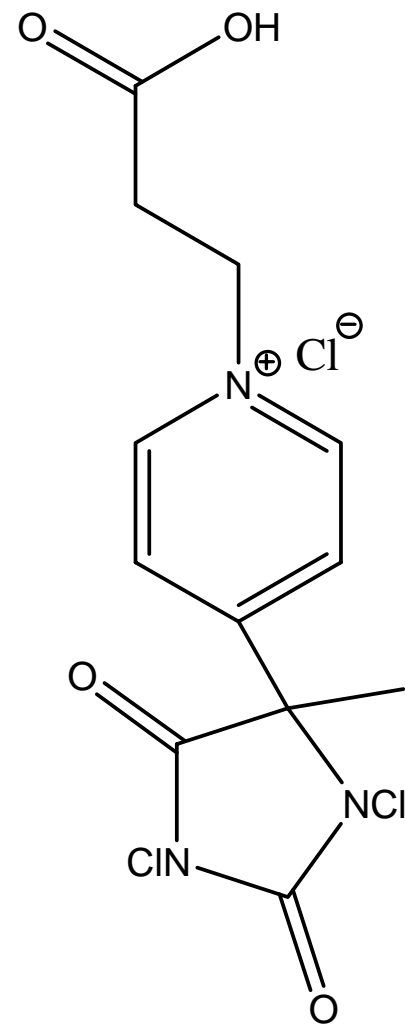
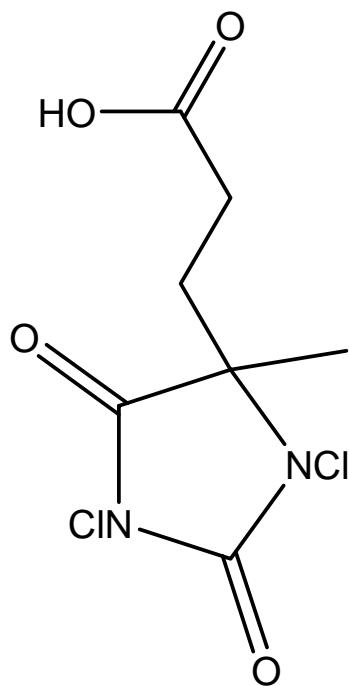
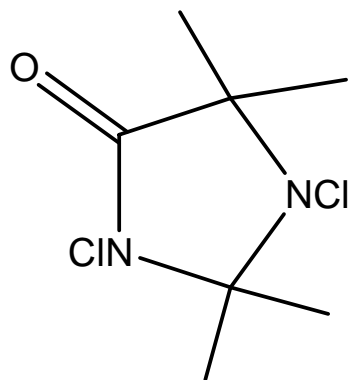
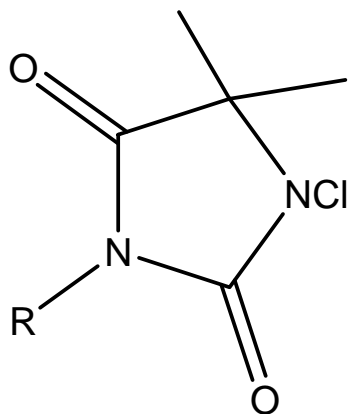
Chloramides



1,3-Dichloro-
5,5-dimethyl-
hydantoin

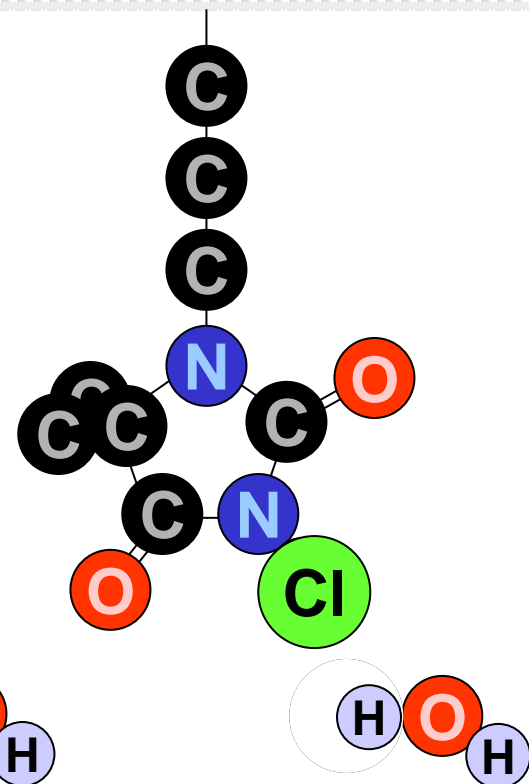
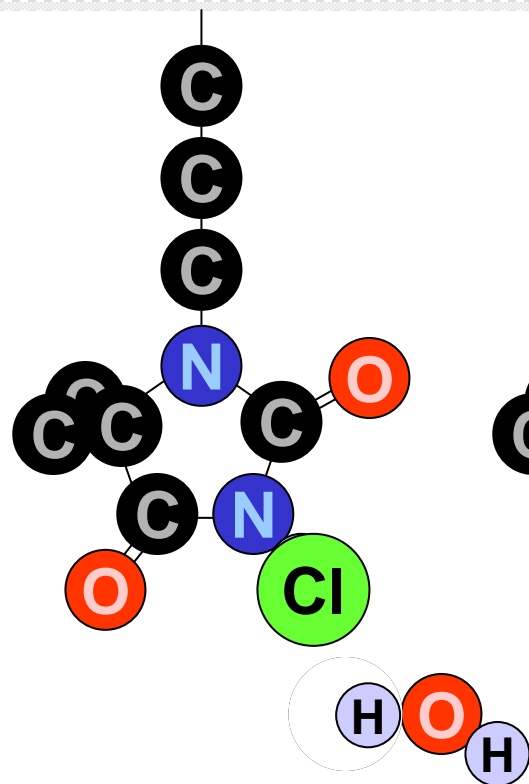
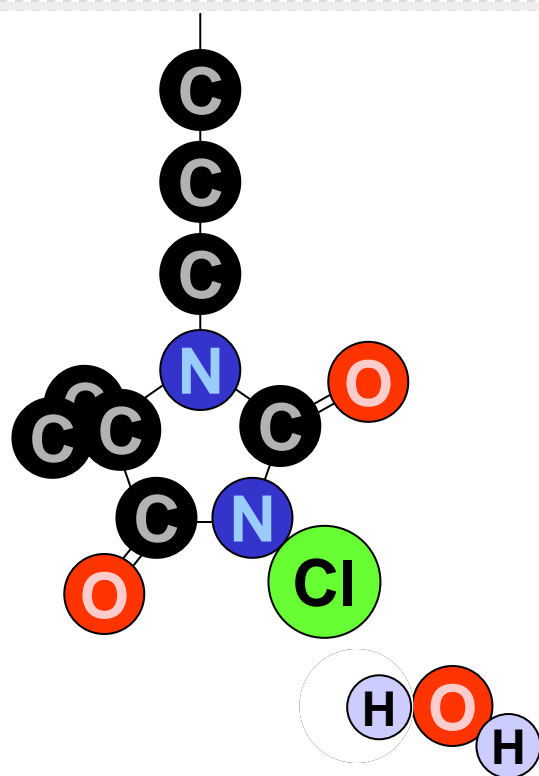
- CWA decontaminant (DANC, RH-195).
- Antibiotic
 - nonspecific
 - acts on contact
 - broad-spectrum
- $>\text{N}^-\text{Cl}^{+1}$
- Benign

Chloramides



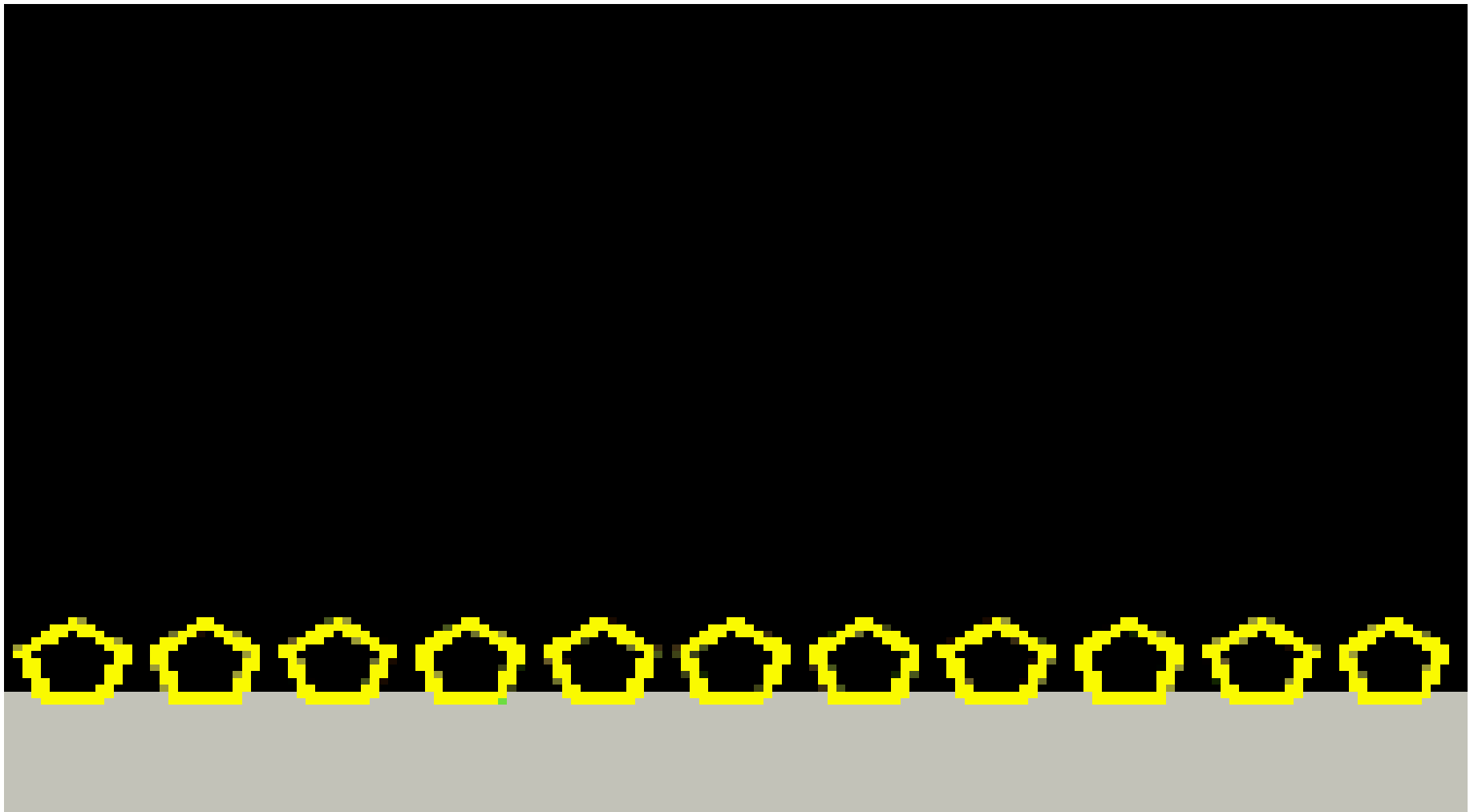
Chloramides of the World...

Regenerate!

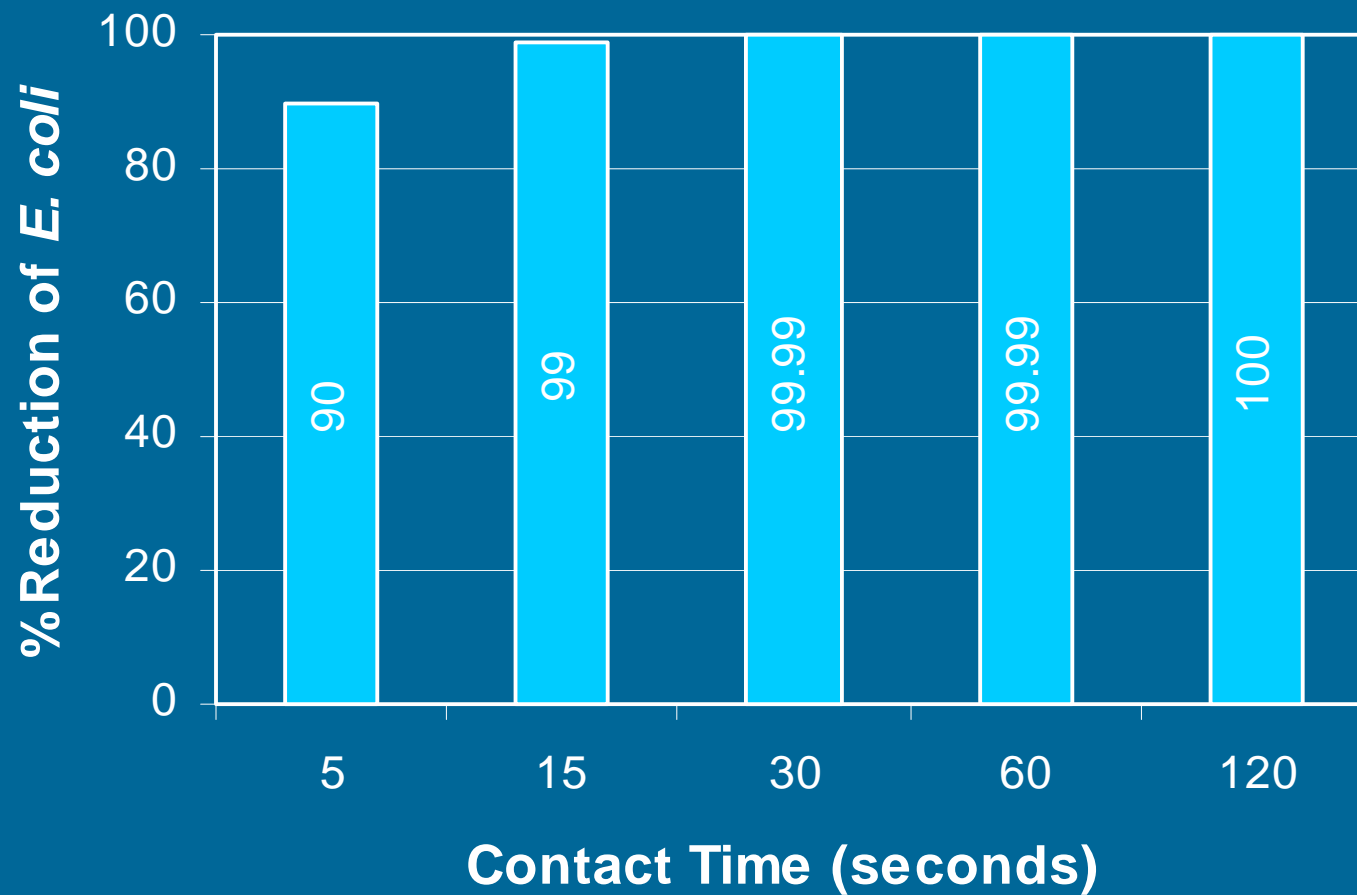


Chloramides of the World...

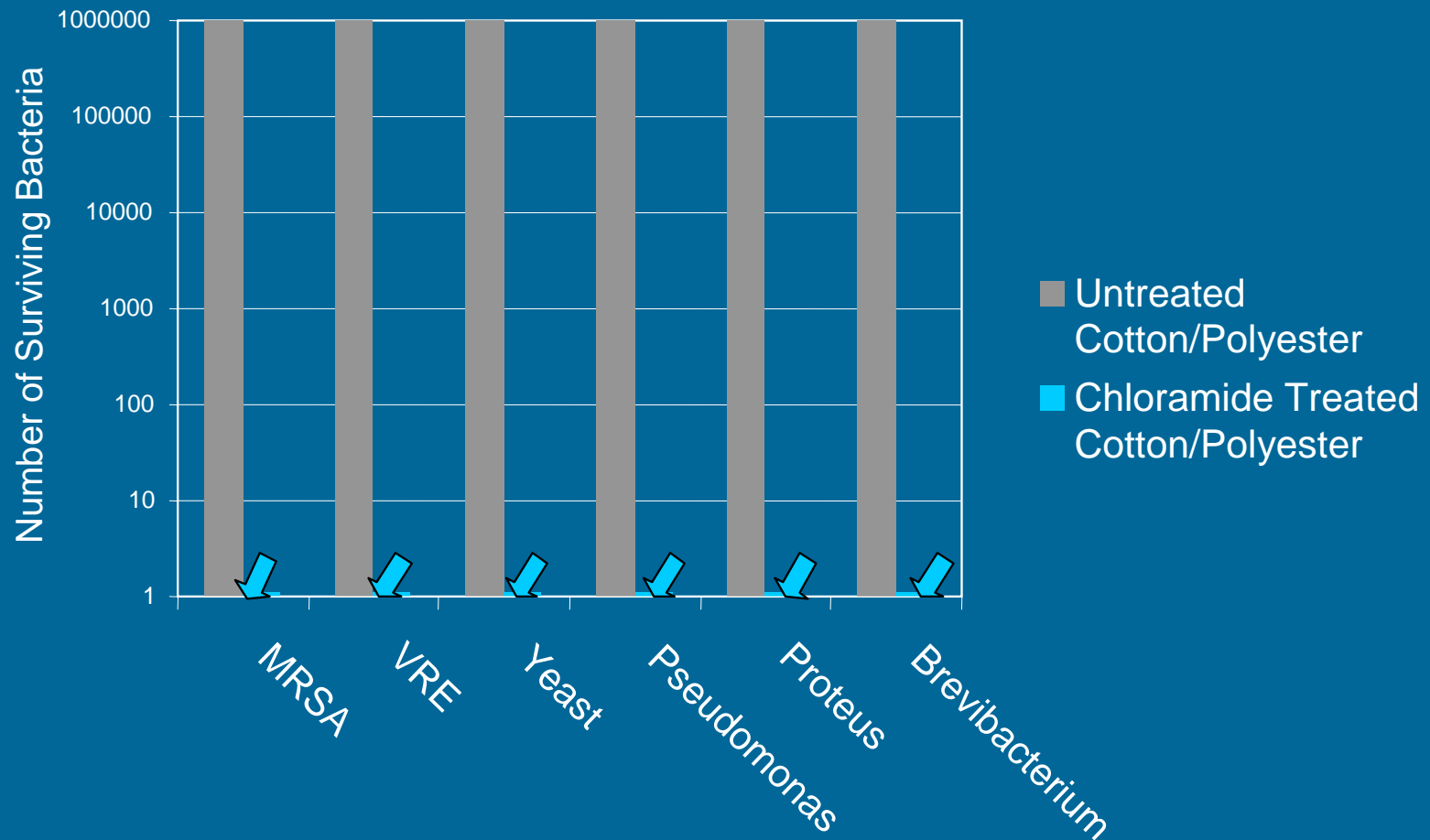
Regenerate!



Chloramides Kill Bugs...



Indiscriminately!



After two minutes exposure

Including the Ones We Care About

Microorganisms	Disease
<i>Escherichia coli</i>	Gastroenteritis
<i>Staphylococcus aureus</i>	Abscesses, wound infection
<i>Salmonella choleraesuis</i>	Gastroenteritis
<i>Shigella</i>	Gastroenteritis
<i>Candida albicans</i>	Yeast, diaper rash
<i>Brevibacterium</i>	Diaper rash
<i>Pseudomonas aeruginosa</i>	Skin & lung infection
<i>Tricophyton mentagrophytes</i>	Fungus, Athlete's Foot & Jock Itch
<i>Vancomycin resist. Enterococcus</i>	Antibiotic resistant bacteria
<i>Staphylococcus epidermidis</i>	Foot odor

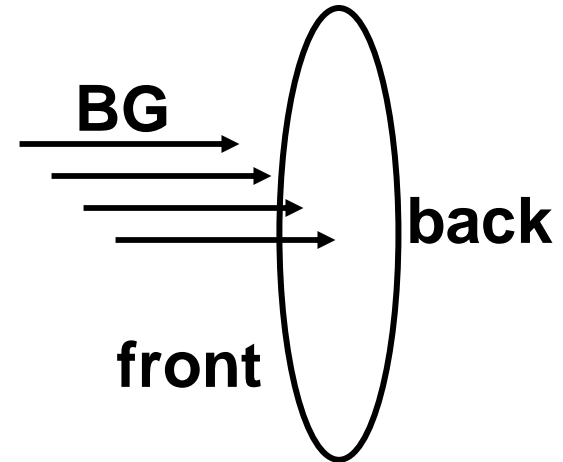
Including the Ones We Care About!

AEROSOL CHALLENGE TEST

BG Spores, 10 min flow

525-675K Spores, 1 hr Incubation

Plate Back Surfaces and Count



RESULTS

	Penetration	Front	Back
SAMPLE	(%)	(counts)	(counts)
Shell/Espun	3.0	36,000	1,150
Shell/Espun/Chloramine	2.7	29,000	720
Shell/Coated/Chloramine	9.6	1,610	0

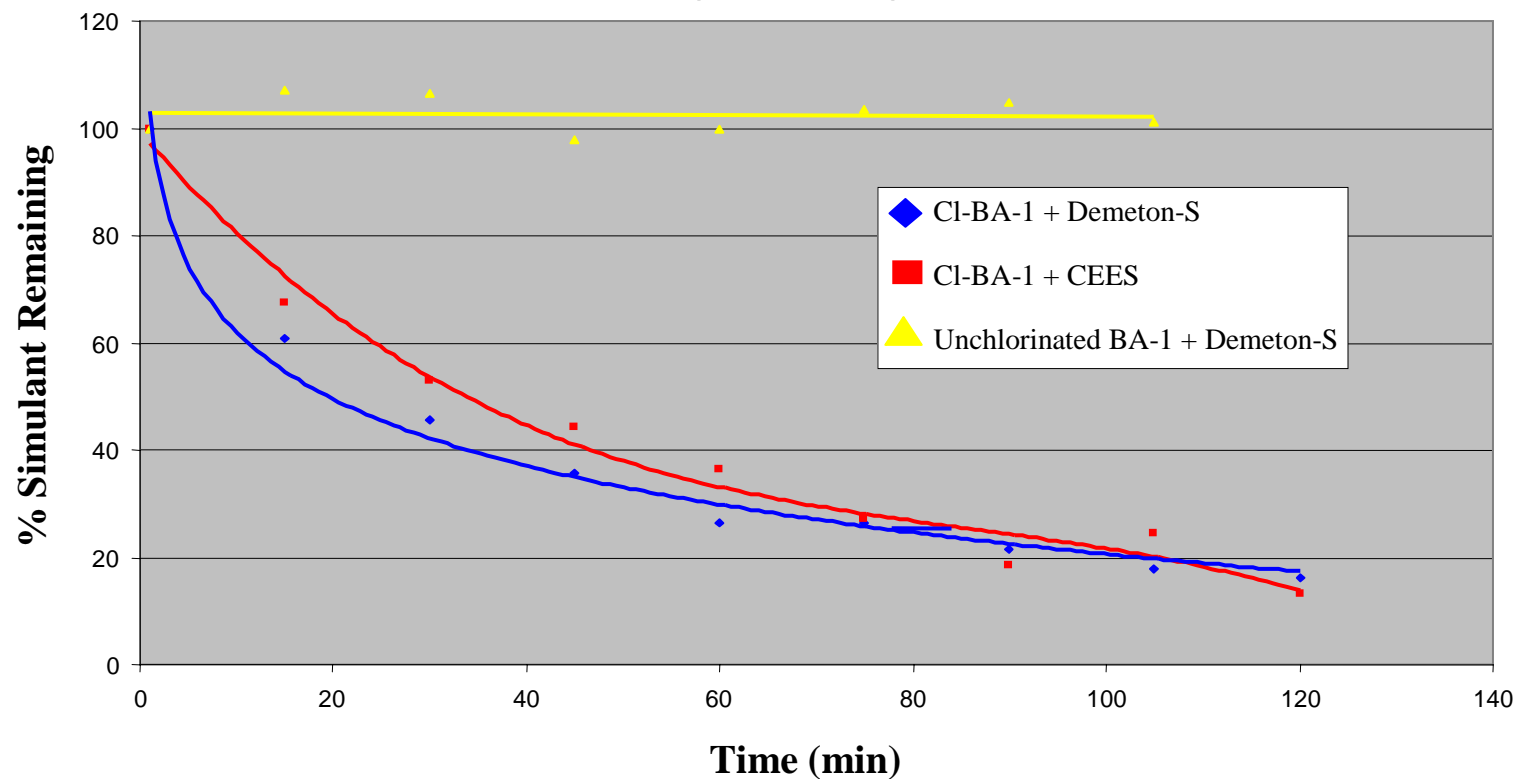
Practical Experiment



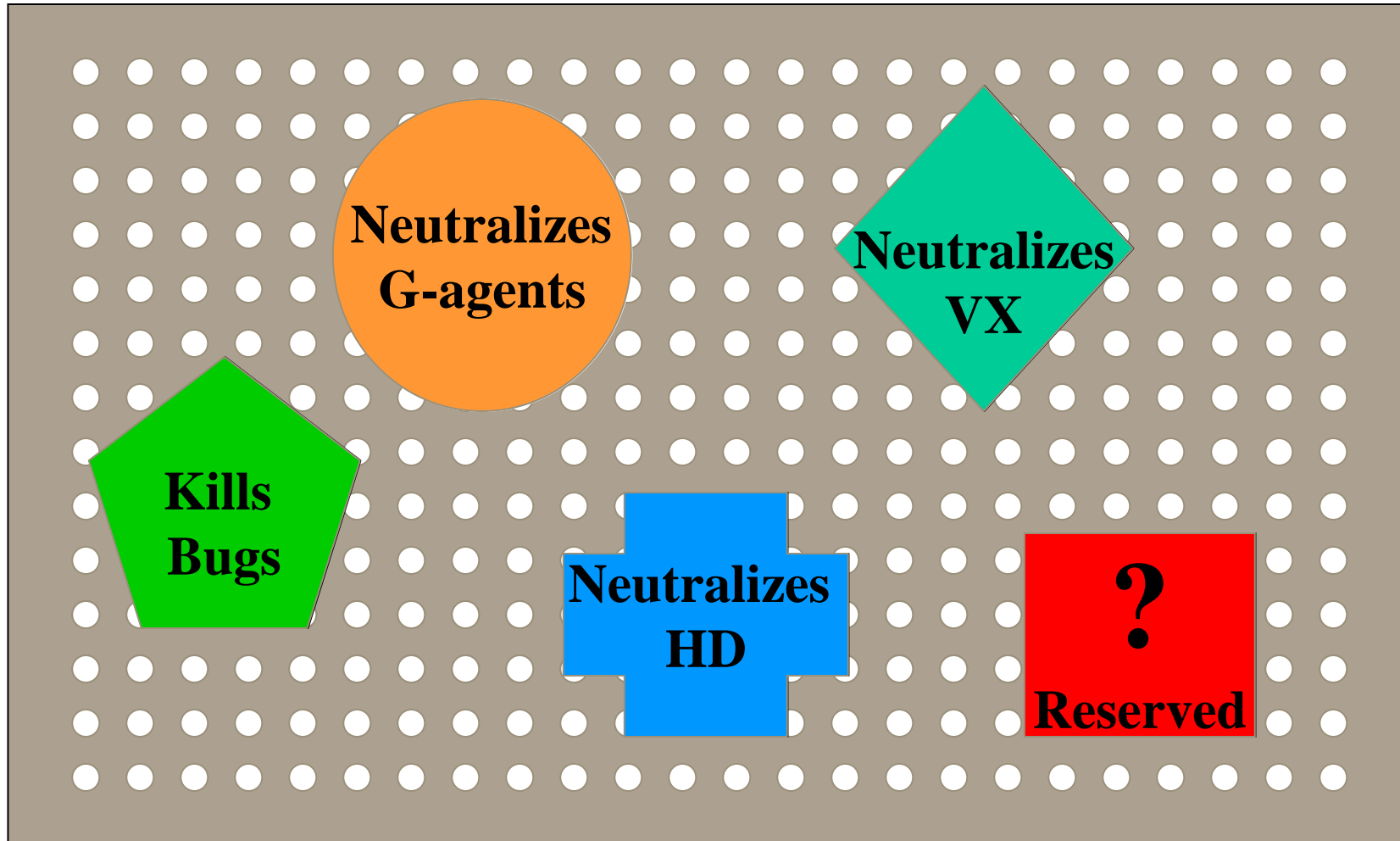
- reactivity regenerable with Cl_2 concentrations of <10 ppm
- zero colony formation from a *Pseudomonas pseudoalcaligenes* JS45 challenge after three, six, nine and twelve months w/o recharging

Chloramide Reactivity to Chemical Agent Simulants

**Oxidation of Chemical Agent Simulants by
Chlorinated BA-1 Fabric
(in acetonitrile)**



What We Want



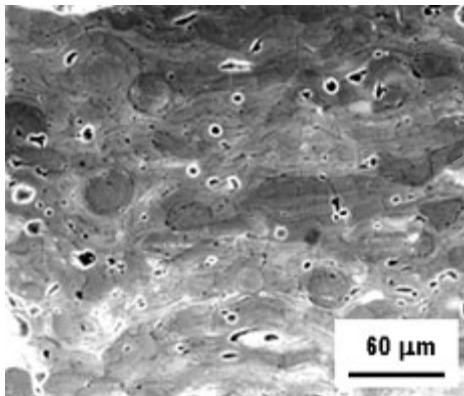
We're Getting There

HOOC

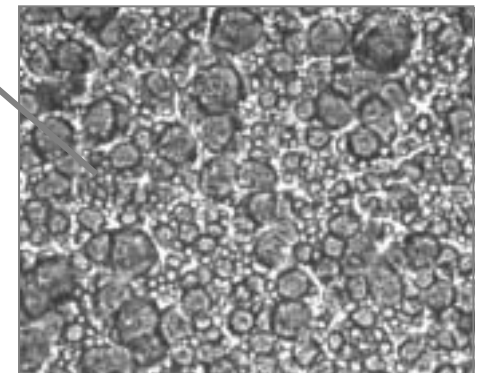
COOH

Reactive Coating Formulation

- COTS coatings were evaluated for desirable barrier characteristics, ease of application, cost, and compatibility with reactive monomers
- Waterborne, thermoplastic poly(vinylidene fluoride) coating systems were chosen primarily for its barrier properties and ease of incorporation of the reactive component
- Stable coating emulsions containing reactive nanoparticles were successfully formulated



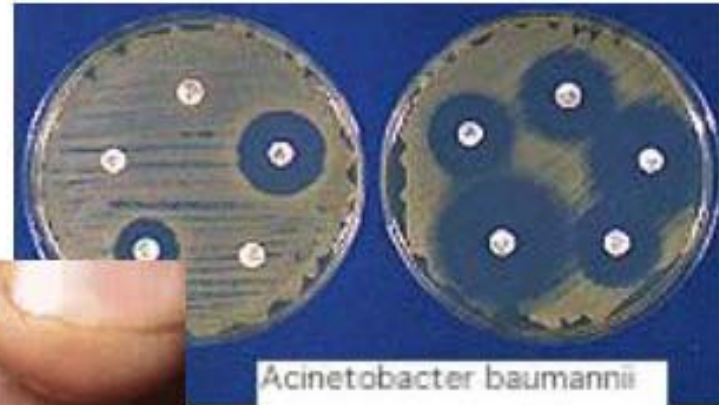
Reactive nanoparticle powder bound in breathable fluoropolymer coating.



Relevant Publications

- 1. Worley, S D; Li, F; Wu, R; Kim, J; Wei, CK; Williams, J F; Owens, J R; Wander, J; Bargmeyer, A M; Shirtliff, M E, 'A Novel *N*-Halamine Monomer for Preparing Biocidal Polyurethane Coatings,' submitted; *Surface Coatings International Part B, Coatings Transactions*; AFRL-ML-TY-TP-02-4629, Air Force Research Laboratory; Tyndall AFB, Florida (2002).
- 2. H. Lomasney and C Lomasney, National Science Foundation Phase I SBIR #1208081 Final Report “Cost Effective Production of Alumina Nanoparticles for Anti-Corrosive Coatings”, Isotron Corporation (2002).
- 3. J. Lin, C. Winkelmann, S.D. Worley, J. Kim, C-I. Wei, U. Cho, R.M. Broughton, J.I. Santiago, J.F. Williams, J. Appl. Polym. Sci., in press.
- 4. 1. Kuhm, J O, 'Acute Dermal Irritation Study In Rabbits,' *Treated Fabric (HTC) Final Report*; Laboratory Study NO. 5650-00; Oppts NO. 870.2500; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Acute Dermal Irritation Study In Rabbits,' *Control Fabric Final Report*; Laboratory NO. 5649-00; Oppts NO. 870.2500; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Acute Dermal Irritation Study In Rabbits,' *Activated Fabric (aHTC) Final Report*; Laboratory NO. 5652-00; Oppts NO. 870.2500; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Acute Dermal Toxicity Study In Rats,' *Activated Fabric (aHTC) Final Report*; Laboratory NO. 5651-00; Oppts NO. 870.1200; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Skin Sensitization Study In Guinea Pigs,' *Activated Fabric (aHTC) Final Report*; Laboratory NO. 5655-00; Oppts NO. 870.2600; 10 July 2000, Stillmeadow Incorporated; Sugar Land, Texas.

Applications



Infection Control

Applications



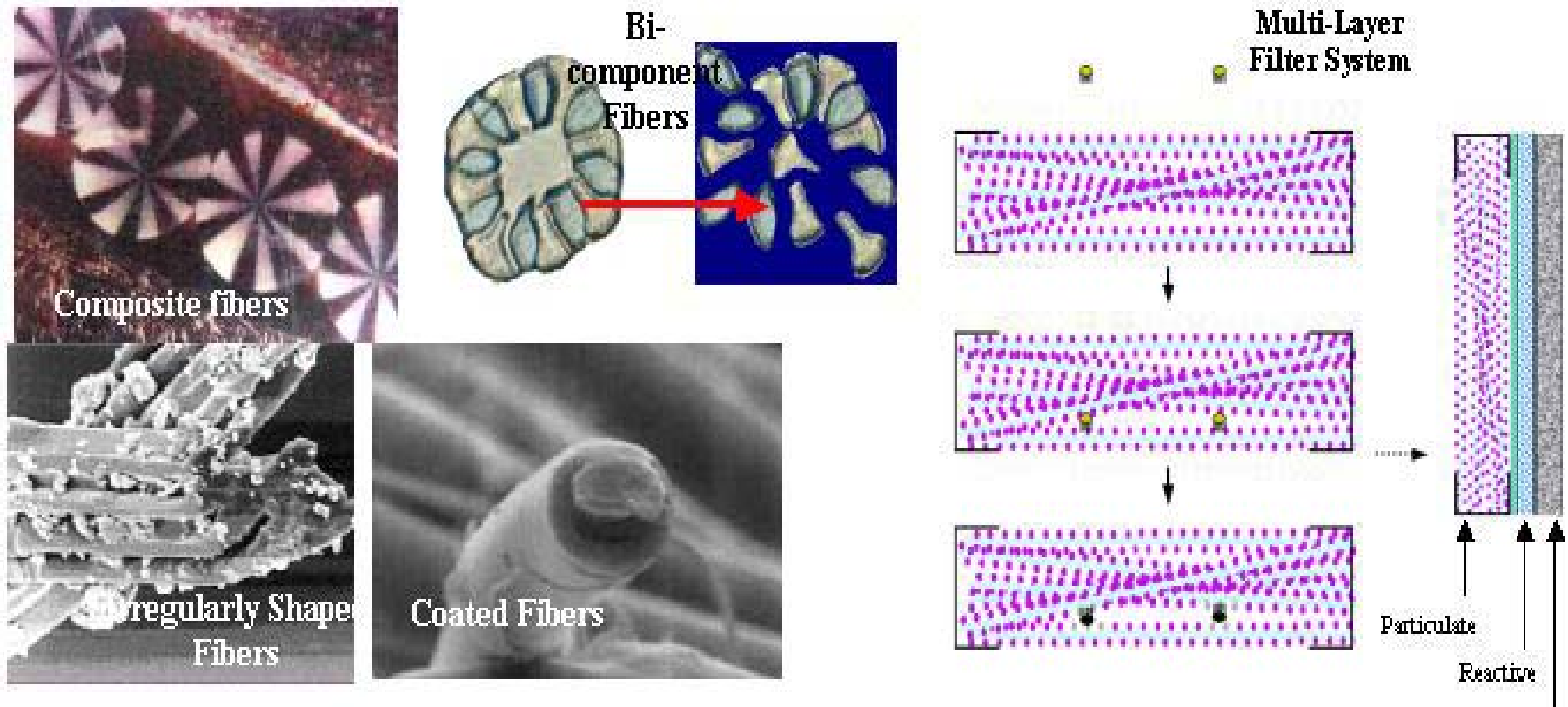
**Biocidal coatings for food preparation
areas and latrines**

Applications



**Reactive filtration for
water purification**

Applications



Reactive low pressure drop air-filtration media for collective and individual protection

Applications



Applications



Applications



**CB hardened
self-decontaminating
coatings**

Self-decontaminating uniform

**Air- and light-
permeable
antibacterial
fabric**

